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While in DEP, recruits are left with time to pursue other career opportunities. In general, the longer a recruit remains in DEP, the higher the possibility that he or she will renege on the enlistment contract. When this occurs, the recruit becomes a DEP loss. USAREC estimates that approximately 15% of the enlistment contracts become DEP losses. Based on an estimated cost of \$5000 per recruit and 13,400 annual DEP losses, the Army estimates it spends approximately \$67 million each year on DEP loss, a considerable sum during the current budget cutting environment.

B. PROBLEM STATEMENT

On a quarterly basis, USAREC analysts must set monthly recruiting goals for each of its four recruiting brigades. The quotas simply specify the number of contracts each brigade must enlist each month. To set these quotas, the analysts must consider three main factors: the DA recruiting requirements, the USAREC recruiting policies and the expected DEP loss. To account for the expected DEP loss, USAREC simply increases the DA mission by 15%. Although this method is effective, it does not account for the differences in expected DEP loss for the different groups (i.e., female, male, high school graduate, non high school grad, etc.) within the recruit population. Thus, the goal of this thesis is to

develop a method which accounts for DEP loss more efficiently in setting the monthly recruiting quotas.

C. APPROACH

The problem of setting the monthly recruiting quotas involves two areas of operations research: statistics and optimization. Statistics is used to estimate the probability a recruit will become a DEP loss. Given these probabilities, the problem of setting the recruiting quota is formulated as an optimization problem with the objective of minimizing DEP losses.

D. ACCOMPLISHMENTS

In achieving the above goal, this thesis made two major accomplishments. One is the estimation of the probability of a recruit becoming a DEP loss. The Army groups recruits into 22 classifications based on their gender, Armed Forces Qualification Test (AFQT) score, education and whether or not they have had prior military service. The probability of DEP loss depends on these 22 classifications along with the length of time a recruit remains in the DEP. Based on the recruiting data from 1988 to 1992, this thesis provides estimations of DEP loss for each combination of classifications and DEP length. By themselves, these probabilities provide USAREC with information useful for setting recruiting strategies at all levels of command, i.e., from the headquarters down to the

recruiters. Furthermore, they also identify classifications that should be avoided if expenses are to be kept to a minimum.

The other accomplishment deals with an application of these probabilities in setting the monthly recruiting mission at the headquarters level. This thesis formulates the problem of setting monthly recruiting missions as an optimization problem with the objective of minimizing the number of DEP losses. The main data for this problem are the DEP loss probabilities, for they determine the expected number of DEP losses. The optimization model is implemented in the General Algebraic Modeling System (GAMS). Preliminary results indicate that the model facilitates the process of setting the monthly recruiting mission as well as allows for analysis of various recruiting policies.

There are several alternatives to reduce the cost of DEP loss. First, USAREC could increase the required contact time between recruiters and their DEP recruits. These contacts include phone conversations and personal contacts in the form of social or Army related activities. These events are designed to maintain a recruit's interest in the Army and provide the recruiter with the setting to discuss the recruit's contractual obligation along with the continued career opportunities that exist in the Army. Second, the Army could exercise its legal right, forcing recruits to honor their enlistment contract. The contract is a legal document binding both parties to the terms therein. To date, the Army has not chosen to exercise this option. And finally, USAREC could incorporate expected DEP losses into their operational planning. In this case, a recruit is viewed as a commodity which is perishable with time, and recruits in DEP serve as an inventory to fulfill the Army's future demand for soldiers. However, the longer the recruits remain in DEP, the more likely they will become a DEP loss. This suggests a just-in-time inventory policy, which is not implementable for two reasons. First, recruiting is not a deterministic process. The number of recruits can vary greatly from month to month. Second, a minimum of one month DEP is required for performing a required background check on each recruit. Thus, a DEP is a necessary part of recruiting and should be efficiently managed.

B. THESIS OBJECTIVE

This thesis focuses on the last alternative to reduce the cost due to DEP loss. In particular, this thesis considers the problem of managing DEP loss as an optimization model and uses statistical techniques to estimate inputs to the model. One important input requiring statistical estimation is the probability of a recruit becoming a DEP loss. This probability depends on the characteristics of the recruit and the length of time he or she must spend in the DEP.

C. THESIS ORGANIZATION

Chapter II introduces the recruiting process within USAREC. Chapter III describes the optimization model. The model provides the best combination of recruit characteristics and DEP length that satisfy the needs of the Army. Chapter IV describes the statistical techniques used to estimate the DEP loss probability associated with each recruit characteristic and DEP length combination. It also studies the variation of DEP loss probabilities on a quarterly basis. Chapter V discusses the implementation of the optimization model. Finally, Chapter VI summarizes the results of the thesis and presents recommendations for future study.

Under the direction of the Commanding General, these directorates coordinate and support the recruiting effort for the entire U.S. Army. The next level in the organization consists of four brigades, each responsible for recruiting in one of four separate geographical regions of the continental United States (CONUS). Under each brigade is a collection of battalions which are generally responsible for recruiting in one or two states. Then, there is a collection of companies in each battalion and, similarly, a collection of stations in each company. The recruiters producing enlistment contracts (i.e., On-Line Production Regular Army (OPRA) recruiters) are located at the stations. The OPRA recruiters form the sales force for the Regular Army (RA). The Army Reserve's mission is recruited by USAREC Reserve Recruiters working alongside the RA recruiters. This thesis only addresses the RA recruiting effort.

Currently, USAREC contains a total of 4 brigades, 42 battalions, 222 companies, 1495 stations and 4200 OPRA recruiters. These numbers are expected to change in the near future due to the ongoing Army force reduction and realignment process.

2. Interactions With DCSPER

It is the Directorate of Personnel Management at DCSPER, who establishes the Army's future personnel needs and sets the Department of the Army (DA) accession mission for

for its companies and so on until the mission finally reaches the recruiters. On average, a recruiter is expected to produce between one and two contracts per month.

C. RECRUITING PROCESS

To produce a contract in a given month, recruiters perform duties much like a salesman. In fact, they sell the Army benefits to American youths predominately between the ages of 17 and 21. These recruiters begin by making contacts with potential recruits at high schools, recruiting stations or through informal introductions. Once these young men and women become interested in joining the Army, they are given a physical and mental (AFQT) test to determine eligibility. Any AFQT score below 26 is an automatic ineligibility.

If the prospect is eligible to join the Army, he or she is processed for enlistment at a Military Entrance Processing Station (MEPS). It is at the MEPS where the prospect usually selects a career path and signs a contract agreeing to join the Army. However, the recruit does not become a member of the Army until he or she returns to the MEPS, is evaluated for continued eligibility, swears in to the active military and departs for a basic training installation.

During the period between signing the contract and the beginning of basic training, each recruit is enrolled in the DEP. While in DEP, the recruit is responsible to contact and verify eligibility with his or her recruiter on a regular

basis. It is the responsibility of recruiters to insure that each of their recruits eventually enters basic training. If, while in DEP, a recruit decides not to join the Army, i.e., he or she becomes a DEP loss, the recruiter must replace the DEP loss with a new contract of the same mission box classification.

contract days in FY94, then contracts written in October should be (approximately) 7.6% (19/250) of the total FY94 contracts.

d. Time in DEP Requirement

As mentioned before, every recruit enters the DEP once he or she signs the enlistment contract. The number of months a recruit remains in the DEP ranges from a minimum of 1 month to a maximum of 12 months. High school recruits must remain in the DEP until after their graduation date.

e. HSDG NPS-A Quality Mix Requirement

Operationally, it is more time efficient to recruit high school seniors than graduates. Recruiters request to meet with all seniors on a single visit to a high school. On the other hand, recruiters must generally visit high school graduates at their home or place of work individually. This requires more time and effort by the recruiter.

In terms of DEP loss, it is more effective to recruit high school graduates than seniors. Experience indicates that seniors exhibit higher DEP loss probabilities than do graduates with similar service, gender and mental aptitude.

To balance the time and DEP loss factors, USAREC requires that GMA make up approximately 70% of the combined GMA and SMA contracts. A similar rule applies to the GFA and

probability determines the additional number of contracts USAREC must produce in order to offset the losses during DEP. The estimation of this probability is the topic of the next chapter.

IV. ESTIMATING DEP LOSS PROBABILITIES

The DEP loss probability is the probability that a recruit becomes a DEP loss prior to leaving the MEPS for basic training or MIT. Intuitively, this probability varies with the time a recruit must stay in the DEP. From past experience, USAREC analysts indicate that the DEP loss probability is also a function of gender, mental capability, education, age, military service history, local unemployment rate, career choice (i.e., Military Occupational Specialty or MOS), etc. To limit the scope of this thesis, the sections below focus on estimating DEP loss probability as a function of time in DEP and the 22 mission BOX classifications. In doing so, factors such as gender, education, military service history and mental capability are included in the estimation. In addition, such estimation is well suited for the missioning problem described previously.

The outline for this chapter is as follows. The first section describes the data base maintained by USAREC. The second section discusses some preliminary analysis and irregularities in the data due to changes in recruiting policy during the past five years. The third section tests the overall differences in DEP loss probabilities by quarter. Finally, the last section provides procedures for estimating the DEP loss probabilities.

V. MODEL IMPLEMENTATION AND ANALYSIS

The missioning problem described in Chapter III was implemented using GAMS [Ref. 5] on a 80486-33Mhz personal computer. To insure that the model always produces a solution, all constraints are made elastic. To do so, an artificial (or elastic) variable is added to each constraint to represent the amount of possible violation. In the objective function, each artificial variable is assigned a large penalty cost. When the missioning problem has a feasible solution, the optimal values for these artificial variables are zero. Otherwise, an optimal solution with non-zero artificial variables indicates the problem is infeasible and provides information as to which constraints can not be satisfied. To make the problem feasible, USAREC analysts can then modify their input data or parameters accordingly. The sections below describe data inputs, model outputs and sample analyses.

A. DATA INPUTS

Data necessary for determining an optimal contract mission for the first quarter of FY94 is used to illustrate and validate outputs from the model. The basic data inputs are summarized in Table XII. The number of required accessions and working days in each month are the same as those listed in

where, as before, \hat{p}_{br} and N_{br} are the point estimate of the DEP loss probability and the number of observations for BOX b and DEP duration t , respectively. The number 1.96 is the 97.5 quantile of the standard normal distribution. When isotonic regression is used to estimate the DEP loss probability, N_{br} is set at 30 to insure that the upper limit is no larger than one.

Part of the inputs to the missioning model are the estimates of how many contracts (by mission BOX) from previous quarters will actually access into the Army during the missioning quarter and beyond. These estimates should be functions of the conditional DEP loss probability which is a topic for future research. In this implementation, USAREC analysts provided the estimates which they refer to as the NETDEP matrix (see Appendix D).

B. MODEL OUTPUTS

Using the input described above, the resulting optimization problem contains 3,899 (continuous) variables and 115 constraints. The problem requires 1.8 cpu minutes on the 80486-53Mhz personal computer to produce an optimal solution.

The GAMS implementation of the missioning model summarizes the optimal solution in the form of output reports. There are a total of five different reports (see Appendix E). Four of which provide information regarding the feasibility of the

recruiting capacity for each month. The recruiting capacity is the number of contracts that can be written in a given month. This number is based on the number of working or recruiting days in a given month (see Table V in Chapter III), the number of recruiters and the write-rate of 2.0 contracts per month. If the number of contracts exceed the recruiting capacity in a given month, SHORTFALL will contain a positive number representing the number of contracts over the capacity, indicating that the inputs yield an infeasible problem. In this case, the analyst must increase the number of recruiters, write-rate or reduce the number of accessions required during a given month. In addition, the difference between the number of expected accessions and contracts is the number of DEP losses resulting from each month's contracts. For example, of the 6384 contracts written in October, 513 are expected to become DEP losses.

C. SAMPLE ANALYSES

To illustrate the potential of the missioning problem as a tool to aid in the decision making, two sample analyses are provided below. One concerns the proportion of females and the other concerns the contracts produced in FY94 to satisfy requirements in FY95.

VI. CONCLUSION

A. SUMMARY

This thesis addresses the problem of determining the number of contracts to be recruited each month by Army recruiters. This missioning problem involves two areas of operations research: statistics and optimization. The statistical aspect involves estimating the probabilities that contracts will eventually become accessions based on the binomial assumption and isotonic regression. Using the probability estimates, the problem is formulated as a linear program that maximizes the expected number of accessions (or minimizes the number of DEP losses). The constraints in the problem include requirements established by DCSPER and USAREC.

The model for the missioning problem is implemented in GAMS and tested using data provided by USAREC analysts. Model outputs were presented and validated by USAREC analysts. Among these outputs is the optimal monthly level of contract mission for each mission BOX during the current and following fiscal years.

Although USAREC assumes a 15.0% DEP loss when setting their monthly mission, Table X in Chapter IV shows that only 11.46% of their contracts became DEP losses. Moreover, the model outputs indicate that, when the contracts are optimally

missioned, the expected DEP loss probability can be reduced from 11.46% to 8.59%. This translates to nearly \$11 million annual saving, a considerable sum during an austere budget environment.

In addition to providing the optimal missioning levels, the model can be used as a tool to analyze the impact of various policies. In particular, Chapter V examines two policies. One concerns the percentage of females among the new recruits to be accessed into the Army. Historically, females have higher DEP loss probability than males. The model is used to compute the expected DEP loss and associated cost as the percentage of required females varies between 10.8% and 20.8%. The other policy concerns the percentage of NPS-A quality recruits. Again, the model is used to evaluate the impact in terms of DEP loss and associated cost as the percentage of required NPS-A quality recruits is increased.

B. AREAS FOR FUTURE RESEARCH

This thesis identifies two topics for future research. They are described below.

1. Conditional DEP Loss Probabilities

As discussed in Chapter V, part of the inputs to the missioning model requires users to estimate the number of accessions that would be generated by contracts written during previous quarters. Such estimates should be functions of the conditional DEP loss probability. Assume that an individual

is required to be in DEP for ten months. Given that eight months have elapsed and the individual has not become a DEP loss, the DEP loss probability should be conditioned on the fact that he or she has already been in DEP for eight months. Statistical techniques that accurately estimate the conditional DEP loss probabilities must take into account the fact that recruiters often delay reporting DEP losses in order to make the recruiting mission in a given month.

2. Missioning by Brigade

The model described in Chapter III addresses the missioning problem at the headquarters level. The next step in the process is to allocate the monthly mission at the headquarters level to the next level in the hierarchy, which is the brigade. Such allocations should be optimal, e.g., minimize expected DEP losses and consider the socio-economic factors, such as unemployment rate, education level and median income, in each brigade's recruiting territory. These socio-economic factors indirectly determine the supply of individuals with high propensities to enlist into the military in each of the geographical areas.

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